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(57) Abstract

A method of laser-beam cutting stainless steel, other high-alloy steel materials, and aluminium or aluminium alloys while using nitrogen as a cutting gas. According to the method, there is used nitrogen which contains oxygen in a small amount corresponding to 0.1-10 volume-%. The oxygen content is preferably 0.5-5.0 volume-%. The invention also relates to a gas composition for use when carrying out the method.

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A method of cutting by laser and gas composition for use in such cutting

The present invention relates to a method of laser-beam cutting stainless steel, other high-alloy steel materials, aluminium or aluminium alloys, while using a nitrogen/oxygen mixture as a cutting gas. The invention also relates to a gas composition for use when carrying out the method.

Laser-beam cutting is an established technique used for cutting many different types of materials. The laser used is normally a high-power CO_2 laser, although other types of laser may be used, for instance Nd-YAG lasers.

In laser-beam cutting, the laser beam is focused onto the workpiece to be cut and the cutting gas is delivered coaxial with the beam at the same time. The cutting gas is delivered under high pressure, up to 30 bars, and serves several different purposes. For instance, because of the high speed at which the cutting gas is delivered, it assists in removing molten material and slag from the cut, therewith preventing the formation of burrs and adhesion of slag products. The gas also shields the focusing optic of the laser from metal splashes during a cutting operation.

The cutting gas may either be reactive or inert, depending on application. It is usual to use highly pure oxygen as a reactive cutting gas. The use of oxygen amplifies heating of the workpiece by the laser beam as a result of an exothermic reaction between supplied oxygen and the material to be cut. This affords a higher cutting speed.

When using an inert gas instead of a reactive gas, it is solely the thermal energy from the laser beam that melts the material, the main purpose of the cutting gas being to blow away molten material and to shield the laser optic. This technique is of particular interest when cutting stainless

steel and other high-alloy steel materials, and also aluminium and aluminium alloys. When nitrogen, N_2, is used as a cutting gas, it is possible to obtain cut surfaces that are completely free of oxide. Although the cutting speed is lower than when using oxygen, this is counterbalanced essentially by the high quality of the cut obtained, among other things a burrless cut.

An object of the present invention is to provide a method of laser-beam cutting with the use of an inert nitrogen/oxygen mixture as cutting gas, which will improve the cutting-speed and reduce gas consumption.

Another object is to provide a cutting gas of suitable gas composition for use when carrying out the method.

The invention is based on the realization that in the case of some applications, a certain degree of oxidation of the surfaces of the cut can be accepted if this will enable a higher cutting speed and a burrless cut to be obtained together with a reduction in gas pressure that results in a lower rate of gas flow and therewith in reduced gas consumption, and the oxidation can be removed in a subsequent stage either mechanically or chemically.

According to the present invention, the laser-beam cutting method defined in the first paragraph is mainly characterized by using as a cutting gas nitrogen which contains a small amount of oxygen corresponding to 0.1-10 volume-%. A preferred oxygen concentration is 0.5-5.0 volume-%.

The method provides burrless cut surfaces and the cutting speed is increased in comparison with the speeds achieved when substantially pure nitrogen is used. This is because oxygen is present in an amount sufficient to generate an exothermic oxidation reaction with the base material, which elevates temperature and makes the cutting process more

effective. Gas pressure can be lowered therewith, resulting in lower gas consumption with subsequent savings in costs. Because large amounts of gas are consumed in a cutting operation, a lowering of the gas consumption will result in significant cost reductions.

Because the invention uses nitrogen that is contaminated with oxygen, the invention can be applied in a particularly advantageous and cost-effective manner, by producing the nitrogen on site from the ambient air, while using known filtering techniques, for instance a membrane or PSA technique. The degree of purity of the nitrogen produced is determined so that the amount of oxygen required for the cutting operation will remain in the produced gas as a contaminant. This avoids the transportation and storage of two gases and the necessity of mixing said gases together.

If required in the case of certain applications to improve corrosion properties and weldability, oxides formed on the surfaces of the cut can be removed in a subsequent mechanical or chemical working step. Chemical removal of the oxides can be achieved by etching with a known agent.

The invention also relates to a gas composition for use when laser-beam cutting stainless steel, other high-alloy steel materials, and aluminium or aluminium alloys while using nitrogen as a cutting gas. The gas composition comprises nitrogen with a small oxygen content corresponding to 0.1-10 volume-%. A preferred oxygen content is 0.5-5.0 volume-%.

This gas composition can be obtained conveniently by filtering-out nitrogen from the air, wherein the desired amount of oxygen will be present in the nitrogen gas as an unremoved contaminant.

The use of a gas composition of this nature will provide an acceptable cut quality in the majority of applications, and

will enable the gas pressure, and therewith gas consumption, to be lowered and the cutting speed increased in comparison with cutting while using pure nitrogen.

Naturally, the nitrogen and oxygen may alternatively be transported separately to the working site and there mixed together in conjunction with the working operation, or may be delivered in a premixed state.

CLAIMS

1. A method of laser-beam cutting stainless steel, other high-alloy steel materials, and aluminium or aluminium alloys, while using nitrogen as a cutting gas, characterized by using nitrogen which contains oxygen in a small amount corresponding to 0.1-10 volume-%.

2. A method according to Claim 1, characterized by using nitrogen containing 0.5-5.0 volume-% oxygen.

3. A method according to Claim 1 or Claim 2, characterized by producing the nitrogen on site from the ambient air; and by determining the degree of purity of the gas produced such as to ensure that the gas will contain the requisite amount of oxygen.

4. A method according to any one of Claims 1-3, characterized by following the cutting operation with a mechanical or chemical oxide removal step.

5. A gas composition for use in laser-beam cutting of stainless steel, other high-alloy steel materials, and aluminium or aluminium alloys, characterized in that the gas composition contains nitrogen and a small amount of oxygen corresponding to 0.1-10 volume-%.

6. A gas according to Claim 5, characterized in that the gas contains 0.5-5.0 volume-% oxygen.

7. A gas according to Claim 5 or Claim 6, characterized in that the nitrogen has been filtered from air; and in that the gas contains a requisite amount of oxygen as an unremoved contaminant.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 96/00101

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: B23K 35/38, B23K 26/14
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: B23K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

ORBIT: WPAT

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4724297 A (STEEN E. NIELSEN), 9 February 1988 (09.02.88), column 3, line 44 - column 4, line 33, figures 2,3 -- --------	1-7

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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International application No.
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 4724297	09/02/88	CH-A- 671176	15/08/89
		DE-A- 3619513	17/12/87
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